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ABSTRACT

The monograph describes various aspects of data collection, analysis and data-based decision-making for the regular or special education classroom teacher. Direct and repeated measurement of student progress and program effectiveness is advocated. Four fundamental steps are outlined: (1) identify instructional objectives and collect data on student performance; (2) display the data graphically; (3) examine the data and identify trends; and (4) use basic data decision rules to guide instructional decisions. The concept of "stages of learning" is introduced in relation to use of percent and rate data. Use of correct-to-error ratios and trials-at-criterion standards for setting performance goals is presented. Strategies for determining objectively when and how to change instruction are discussed. Instructional modification involves changing one or more of four basic program elements: general setting events, antecedent events, subsequent events, and the contingency arrangement. Finally, guidelines for implementing data-based instruction and making data-based decisions with students who are low achieving, exceptional and at-risk for dropping out are offered. (Author/DB)

Implementing Data Based Decisions for Instruction[1]

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PREFACE

The merit of conducting direct and repeated measurement on academic performance is well documented. Nonetheless, many teachers do not apply knowledge gleaned from such measures to make day-to-day instructional decisions. This monograph describes various aspects of data collection, analysis and data-based decision-making for the classroom teacher. Direct and repeated measurement of student progress and program effectiveness is advocated. The concept of "stages of learning" is introduced in relation to use of percent and rate data. Use of correct-to-error ratios and trials-at-criterion standards for setting performance goals is presented. Strategies for determining objectively <u>when</u> and <u>how</u> to change instruction are discussed. Finally, guidelines for implementing data-based instruction and making data-based decisions with students who are low achieving, exceptional and at-risk for dropout are offered.

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A Guide to Data-Based Decisions for
Teaching Students with Learning Difficulties

By most accounts, direct and repeated measures are viewed as essential to sensitive evaluation (Fuchs, 1986) and effective instructional programming for students evidencing a range of learning difficulties (e.g., Haring & Krug, 1975; Lovitt, 1977; Smith, 1981; White & Haring, 1980). Available literature on academic achievement amply demonstrates the efficacy of direct measurement procedures. An impressive body of evidence documents direct and repeated measurement as "one of the few variables that reliably predicts growth as a function of teacher effectiveness" (Sailor & Guess, 1983). Use of direct and repeated measures is known to positively affect student achievement and is recognized as fundamental to effective curriculum-based assessment. By comparison, ill defined goals and occasional measurement of student performance are major reasons for the failure of classroom instruction (Deno & Mirkin, 1977).

In spite of overwhelming clinical and research evidence, direct and repeated measurement of student performance for the purpose of verifying the worth of an instructional program is not common practice in education (Tawney & Gast, 1984). While many special education teachers (and some regular educators) are aware that direct and continuous, curriculum-based measurement strategies can be more useful than traditional evaluation approaches, few use them. Part of the lack of data-based instruction by classroom teachers may be that information which will assist practitioners in establishing workable programs and in making data-based instructional decisions is scattered and not widely disseminated. Further, information on data decision strategies is not well understood and often perceived as impractical by the individual teacher.

This monograph is designed to help bridge-the-gap between research and practice and to enable the classroom teacher to employ data-based decisions to assess student progress and to evaluate instruction. Following a brief overview of the problem, a synopsis of how to establish a data-based instructional program is presented. The concept of "stages of learning" is discussed as well as teacher selection and use of percent or rate data in relation to instructional goals and the student's stage of learning. The correct-to-error ratio and trials-at-criterion approaches for determining when to make phase changes (e.g., modify instruction) in an academic program are presented. Guidelines are provided for how to modify instruction once a phase change is indicated. Teachers are encouraged to establish local normative standards. Finally, a set of guidelines for implementing data-based instruction and data-based decision-making is offered to the practitioner.

Direct and Continuous Measurement: The Problem

The value of direct and continuous measures of student performance for the purpose of individualizing instruction, evaluating student progress, and assessing the merits of different instructional approaches is well documented (Lovitt, 1977). Nonetheless, routine collection of performance data for empirically verifying the worth of instruction and making instructional decisions is not common practice among educators (West, 1984) Wesson, King and Deno (1984), for example, found that 82% of special educators polled expressed knowledge of direct and repeated measurement, while only 44% indicated that they actually applied these procedures Tindal (1985) reports that even when continuous measurement systems are employed, teachers do not institute adjustments in instruction with sufficient frequency. Moreover, direct, frequent measures of student performance do not in themselves ensure sound instructional decision-making (Tindal, 1985). Simply stated, direct and repeated measurement is not functional unless instructional outcomes (i.e., data on student performance) control the actual implementation of instructional decisions (Eaton, 1978). In short, although quality day-to-day instruction is predicated on frequent evaluation of student performance (Englert, 1984), widespread implementation of the fundamental state-of-the-art assessment procedures remains unachieved.

The Data-Based Classroom

Data-based instruction can be carried out successfully in (a) elementary, middle or secondary level classrooms, (b) regular education, special education and alternative education programs, and (c) large group, small group and independent teaching arrangements. To establish data-based classroom practices, four fundamental steps will need to be carried out by the teacher: (1) identify instructional objectives and collect data on student performance, (2) display the data graphically, (3) examine the data and identify trends, and (4) use basic data decision rules to guide instructional decisions. These steps are described briefly below and are followed by suggestions for making data-based classroom decisions.

Step 1. Identify objectives and collect data. In order to evaluate whether a specific objective is being achieved within an expected time frame (or has been mastered), it is necessary for the teacher to delineate precisely the instructional task of interest. Fortunately, the majority of academic behaviors taught in our schools are amenable to clear definition and objective evaluation. Direct and repeated measurement of simple academic behaviors such as oral reading, writing words in response to story starters, and writing spelling words is known to yield valid, reliable indices of student performance (Fuchs, 1986). Accordingly, teachers may target dependent variables such as these with confidence.

Once instructional objectives have been targeted, defined and prioritized, data on student performance can be gathered. Jenkins, Deno and Mirkin (1979) propose that an effective data collection system must. (a) yield a fair representation of overall pupil performance, (b) be sensitive to small changes in performance, (c) be flexible and adaptable to various instructional objectives, and (d) be repeatedly and easily administrable. Evans, Evans and Mercer (1986) recommend the use of probes (i e, brief structured, timed tests) administered subsequent to instruction. Timed probes meet the above-mentioned criteria for an effective data collection system. Fuchs (1986) notes that 1 to 3 minute timings (i.e., probes) are practical to administer and technically sound. By systematically controlling the length of the probe, the schedule of the probe session, the type of student response, and format and content of the probe itself, teachers can make reliable comparisons of student performance across time and among students. Assessment of student performance through the use of brief probes can be accomplished strategically in different ways--probes may be teacher administered to individuals or groups, students can administer probes to one another, and students can learn to self-administer probes (see sample probe sheets in Figure 1).

Step 2: Display the data graphically. Each time data are collected on a student's performance using a timed probe, the data should be plotted on a graph. Charting data on a graph provides immediate visual feedback on student performance and enables visual inspection and analysis of the effects of instruction. Two main charting conventions, equal interval and logarithmic paper, are used in education. Examples of equal interval and logarithmic graph paper are presented in figures 2a and 2b, respectively, with the same hypothetical sets of data charted on each.

While the literature clearly substantiates the benefits of data graphing, it fails to support unequivocally one charting convention over the other (Fuchs, 1986). Tawney and Gast (1984) argue that equal interval paper facilitates data analysis and is easier for practitioners to understand (e.g., Figure 2a). Limited investigation of the predictive capacities of the two graphing procedures suggest that a trend line (i.e., a "best fit" line that represents the slope of the data) on equal interval paper may be equally or more accurate than those recorded on logarithmic paper (Fuchs, 1986). However, as West (1984) points out, a logarithmic

Figure 1

Sample Probe Sheets

SUBTRACTS LIKE DENOMINATOR FRACTIONS

$\frac{16}{2} - \frac{2}{2} =$	$\frac{3}{4} - \frac{1}{4} =$	$\frac{17}{12} - \frac{4}{12} =$	$\frac{2}{2} - \frac{1}{2} =$	$\frac{13}{14} - \frac{7}{14} =$
$\frac{3}{9} - \frac{2}{9} =$	$\frac{6}{11} - \frac{4}{11} =$	$\frac{5}{9} - \frac{1}{9} =$	$\frac{8}{12} - \frac{4}{12} =$	$\frac{12}{7} - \frac{6}{7} =$
$\frac{14}{17} - \frac{2}{17} =$	$\frac{5}{8} - \frac{1}{8} =$	$\frac{16}{7} - \frac{5}{7} =$	$\frac{3}{4} - \frac{2}{4} =$	$\frac{2}{3} - \frac{1}{3} =$
$\frac{11}{12} - \frac{7}{12} =$	$\frac{2}{10} - \frac{1}{10} =$	$\frac{4}{6} - \frac{2}{6} =$	$\frac{12}{5} - \frac{4}{5} =$	$\frac{13}{8} - \frac{7}{8} =$
$\frac{5}{9} - \frac{3}{9} =$	$\frac{6}{10} - \frac{4}{10} =$	$\frac{4}{5} - \frac{2}{5} =$	$\frac{12}{3} - \frac{4}{3} =$	$\frac{2}{8} - \frac{1}{8} =$

OCPS ORANGE COUNTY PUBLIC SCHOOLS
PRECISION TEACHING PROJECT
ORLANDO, FLORIDA

Dolch Preprimer
Unit 1

run	big	to	look	we	three	me	a	can	9
down	and	help	my	away	for	it	one	in	18
said	here	we	to	look	in	for	big	my	27
and	one	it	me	away	run	here	said	can	36
three	help	down	a	for	we	my	and	look	45
one	can	help	to	run	me	three	it	down	54
away	here	big	in	to	said	we	look	three	63
run	for	can	one	down	my	said	big	it	72
a	away	me	and	help	in	here	a	said	81
to	look	for	big	we	and	a	it	three	90
away	in	one	my	run	can	me	help	here	99
down	three	run	look	down	away	help	and	me	108
we	to	here	one	my	in	can	it	big	117

Figure 2a

Equal Interval Graph Paper : Number of Correct and Incorrect Words Read Orally in One Minute Under Two Intervention Conditions

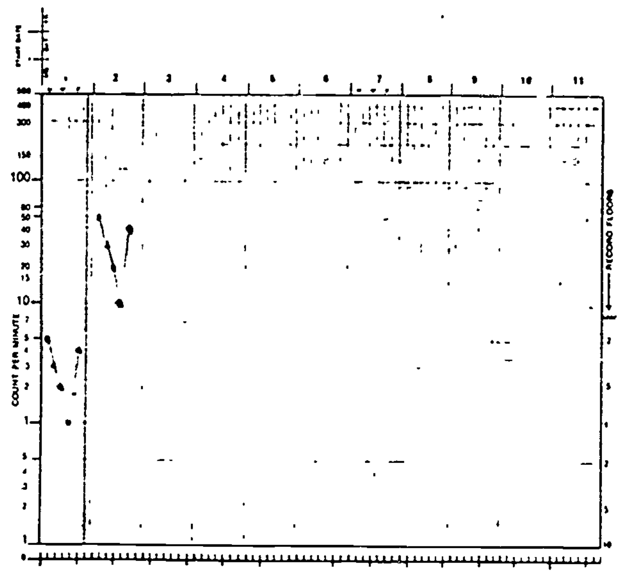
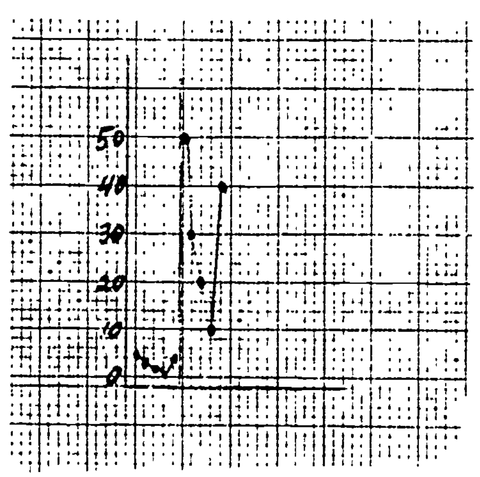


Figure 2b

Logarithmic Graph Paper : Number of Correct and Incorrect Words Read Orally in One Minute Under Two Intervention Conditions



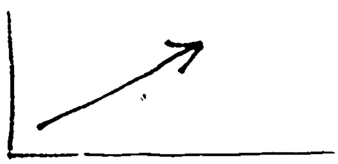
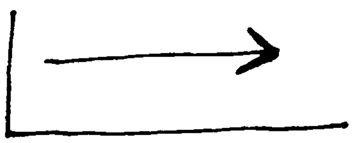
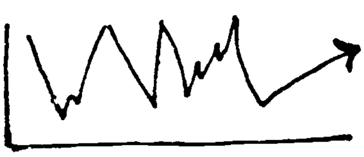
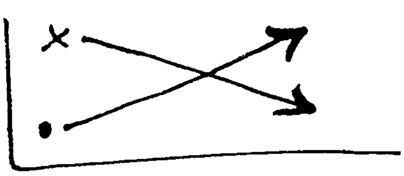
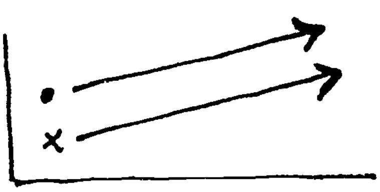
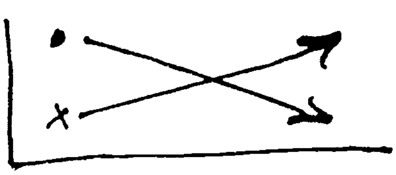
scale (also referred to as a proportional scale) enables the display of a wider range of scores (see Figure 2b), does not distort relative equivalence in scores (compare pictures of Intervention 1 and 2 in figures 2a and 2b), yields a straight or nearly straight line which can serve as the growth/trend line, and provides a picture of relative changes in learning which can be compared directly to one another.

Given present research on charting data, selection of a particular type of graph paper may best be resolved as a matter of teacher preference (Gable, Hendrickson, Evans & Evans, in press). Most of the natural sciences, for example, have decided in favor of logrithmic paper while the education community traditionally has employed equal interval graph paper Frequent use of either chart, particularly in settings serving a large number of students can be made more efficient by: (a) teaching the students to graph their own performance (and the performance of peers) and (b) setting up a data management station for scoring probes, charting performance, and interpreting instructional outcomes

<u>Step 3 Examine the data and identify trends</u>. Visual inspection of frequency data usually reveals one of three basic performance trends These three trends are used to describe <u>correct</u> responses and <u>incorrect</u> responses Once a sufficient sample of student performance has been gathered the three trends typically seen are. (1) an increasing/celerating trend, (2) a decreasing/decelerating trend, or (3) a stable state Figure 4 depicts common trend lines and combinations of correct and error slopes.

Figure 3

Common Trend Lines and Descriptions

Trend	Description
	increasing/celerating
	decreasing/decelerating
	stable/steady
	variable/not under instructional control
	increasing corrects decreasing errors
	increasing corrects increasing errors
	decreasing corrects increasing errors

Once trend lines are identified, the teacher has a solid basis for making data-based decisions In addition to examining the trends in the data, teachers may use data variability, steepness of the trend/slope lines, and student performance on the most recent instructional days to determine the effectiveness of instruction [Readers are referred to Haring, Lovitt, Eaton and Hansen (1978), McGreevy (1986), West (1984), White (1985) and White and Liberty (1976) for greater detail and discussion of charting and analyzing direct and continuous measurement data.]

Step 4 Use basic data decisions rules Kerr and Nelson (1983) define data-based decision making as "using direct and frequent measures of a behavior as a basis for comparing student performance to a desired level, and making adjustments in the students educational program based on that comparison" (p. 344). Decision rules allow practitioners to examine data on student performance and determine when to make program revisions (Eaton, 1978). To help the teacher make sound instructional decisions, basic rules for interpreting trends in the data are useful; Figure 4 provides basic decision rules in relation to common data trends.

Stages of Learning

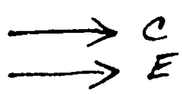
McGreevy (1986) states that learning can be defined as a change in performance across time Lovitt and his colleagues have proposed conceptualizing learning as a process which includes stages ranging from acquisition to adaption (Haring et al 1978). By employing this conceptualization in the classroom, teachers may be better able to plan for and assess the outcomes of instruction

Figure 4

Common Trends and Decision Rules

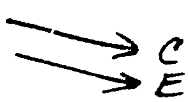
Trend	Decision

The divergence of correct and error trends is the desired outcome of instruction, and indicates good discrimination of stimuli and differential reinforcement of desired behavior.

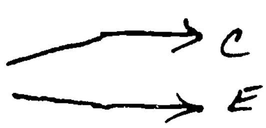


Horizontal and parallel trends mean that a discrimination problem possibly exists.

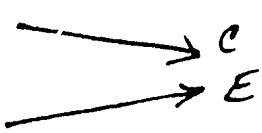
Parallel rising trend lines indicate the possibility that errors are being reinforced.



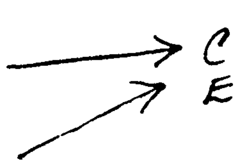
Parallel falling trends indicate the possibility of extinction conditions.



If correct and error trends diverge to a large degree and then run parallel, there is the possibility of a schedule of reinforcement problem.



Convergence of error and correct trends indicates the possibility of discrimination problems and of noncontingent reinforcement.



A rising correct trend with an even more sharply rising error trend possibly indicates a contingency problem arising from subjects hurrying to get finished.

Source: Burney (1976)

West (1984) defines learning as a change in performance and also emphasizes that learning is a process. Correspondingly, he raises the thought-provoking question of what dimension of performance must change in order for educators to agree that learning has occurred? While educators predominantly use percent correct (i.e., accuracy) as the primary proof of learning, accuracy may be viewed as a qualitative (not quantitative) measure of performance (West, 1984). To obtain quantitative measures of performance West recommends the use of rate data.

Based on the research and clinical observations of Lovitt, McGreevy, West and others, a Stages of Learning: Measurement Decision Chart (see Table 1) was designed. This Measurement Decision Chart interrelates four stages of learning (column 1) with the goal of instruction at each stage (column 2) and provides the practitioner with a recommended measure for assessing student performance (column 3). Column 4 states the source from which the standard was obtained.

As Table 1 illustrates, academic progress can be conceptualized as a stepwise advance through four learning stages ranging from response acquisition to proficiency, maintenance and generalization. While empirical data do not validate a rigid learning sequence, it is helpful to classify student learning according to stages in order to select the unit of measurement, determine when to modify instruction, and decide how to adjust intervention techniques.

At the beginning stage of learning, the main objective is for the student to demonstrate correct performance of new skills or knowledge (e g , to add correctly facts with sums to 10). Next, during proficiency--

stage 2, the goal of instruction shifts to include speed as an important dimension of performance (e g, the teacher now requires the student to add correctly 50 facts in one minute). In stages 3 and 4, maintenance

Table 1: Stages of Learning: Measurement Decision Chart

Learning	Goal	Measure	Standard
1 - Acquisition (Initial Learning)	Accuracy	PERCENT Ratios corrects errors Trials-at-Criterion	Expert judgment Functional analysis of "critical effect"
2- Proficiency (Fluency Building)	Accuracy & Fluency	RATE Trials-at-Criterion	Peer referents Adult: child formulae Compare past-to-present mastery
3- Maintenance (Durability)	Retention Endurance	RATE	Peer referents Adult: child formulae Compare past-to-present mastery
4- Generalization (Adaptability)	Expansion Extension	PERCENT or RATE	Mainstream norms Community norms

Adapted from Haring, Lovitt, Eaton & Hansen (1978); Smith (1981)

(response durability) and generalization (response adaptability) are the aim of instruction. During maintenance the teacher is interested in whether the level of fluency attained during proficiency building will be retained 6, 12 or more weeks later. During generalization the teacher may be interested in response application in new circumstances (e.g., computer generated addition facts with sums to 10). Additionally, a student's adaptation and/or modification of a response and its transfer to a novel context (e.g., solving a math puzzle or word problem through the application of addition with sums to 10) is a goal of generalization.

In sum, use of percent data and correct-to-error ratios are advocated during acquisition (refer to Table 1). A trials-at-criterion standard may be useful during acquisition and proficiency. Rate data are preferable for assessing proficiency and maintenance of pupil responses. For measuring performance at the generalization stage of learning, the measure applied will vary, depending on the exact nature of the task. Further discussion of issues related to percent and rate data follows; the utility of corrects-to-errors ratios and trials-at-criterion standards with direct and repeated measurement systems are presented.

Percent Data and Decision-Making

Percent data are used extensively in education even though rate measures may be the most functional indices of pupil performance (Gable, McConnell & Nelson, 1985). Nonetheless, use of percentage is advocated in certain instances. For example, at the acquisition stage of learning the objective is for the student to perform the task correctly. In striving for accuracy the teacher concentrates on response correctness and not on the rapidity with which it is executed. Indeed, teachers often direct learners to take their time and get it right during acquisition (Hendrickson, Gable & Stowitschek, 1985)

In some instructional arrangements, students may be restricted from responding as rapidly as they actually are able (e.g., when spelling words are dictated by the teacher) (Eaton, 1978). When there is a ceiling imposed on response rate, percent data may be the best measure of student learning. Similarly, complex tasks/problems requiring generalization may be more amenable to percent than rate measures (Hendrickson et al, 1985). For example, the teacher may assign students 1 to 3 complex problems to solve and allocate as much time as needed to solve them. In such a case accuracy in application of conceptual knowledge and the execution of different subtasks may be more important instructionally than solving numerous problems in a short time.

Establishing percent criterion standards Haring and his colleagues (1978) report a procedure for establishing a percent growth criterion against which to judge the impact of instruction (Haring, Lovitt, Eaton, Hansen, 1978) This procedure is recommended particularly for instruction that involves the acquisition of new skills. To implement the procedure, three initial measures are obtained and data on the number of items correct are charted (e.g., 6, 10, and 8 correct addition problems) Once the three data points representing student performance are plotted, the median or mid-frequency score, is used as the basis for setting the instructional aim for the next 3 days. For example, if 8 represents the median score, the teacher can establish an instructional goal by selecting a minimum percentage representing an acceptable increase in student performance (e g., 30 %) Next, the median is multiplied by the growth factor selected by the teacher (i.e., 8 x 3 = 2 4). Finally, the product is added to the original median (8 + 2.4 = 10.4) to yield a criterion standard for number of correct responses expected on each of the subsequent 3 teaching sessions. Pupil performance at or above 10.4 indicates that student progress is acceptable within the current instructional program. In contrast, should 1 - 3 data points fall below the newly specified criterion (e.g, 8, 9, and 10), the instructional program would be reassessed and probably modified.

When an instructional aim is almost achieved (e.g., 10, 9, and 11), an additional 1 - 3 data days (i.e., teaching sessions) should be conducted to substantiate this modest subaverage trend before a phase change is made in the instructional program If a poor growth trend is substantiated the instructional program then would be modified. This procedure for setting percent performance standards is repeated about every three sessions until the terminal instructional goal is attained It should be pointed out that probe data need not be collected each day of instruction; however, three or more times a week is recommended (McGreevey, 1986, West, 1984).

Other procedures for establishing percent criteria. A minimum standard of 83 percent accuracy on academic tasks is advocated by some authorities (Howell & McCollum-Gahley, 1986). Stephens (1977) suggests using a variable percent criterion to determine the entry level of the student (as well as setting learning standards). His learning levels include: (a) mastery at 100% correct, (b) learned at 90-99% correct, (c) instructional at 70-90% correct, and (d) frustration at 69% or less correct By demanding that the student achieve a predetermined criterion such as 83% correct <u>across</u> teaching trials, the likelihood increases that instruction will be successful (i.e., be retained and generalize)

Table 2 contains a guide to making phase change decisions. Making phase changes (i.e., program modifications) is presented as a basic 4 step process Step 1 is establishing the performance criterion standard against

Table 2: <u>Four Step Guide to Phase Change Decisions</u>

Step	Activity
1	Establish performance criterion standard (a) percent standard (b) rate standard (c) ratio of corrects-to-errors standard (d) trials-at-criterion standard
2	Evaluate student performance across three (to ten) teaching sessions
3	Judge instruction based on the criterion standard and/or a revised criterion standard
4	Maintain, modify or terminate instruction (Based on Eaton, 1978)

which the student's growth can be measured. Establishing a criterion level is done regardless of the measure employed (e.g., percent or rate) (Examples for setting up percent criteria were described earlier in this monograph.) Step 2 consists of evaluating student performance to ascertain whether the criterion is met. Step 3 requires judging instruction based on the criterion standard established. Step 4 consists of implementing the decision to maintain, modify or terminate the instructional program. As stated, this sequence of steps for making phase change decisions applies regardless of the type of measure employed to assess student performance

Rate Data and Decision-Making

As previously discussed, by using percent alone, knowledge is gained on the degree of accuracy with which a task or steps of a task is/are performed Rate data--frequency of responses in relation to time, go a step further by including response frequency and speed in the measurement process Two other temporal measures of behavior, latency and duration, are needed less often by teachers and consequently are not discussed. Teachers should note, however, that latency and frequency have an inverse relationship in that the greater the amount of time needed to respond, the fewer responses a student is able to make. The steps shown in Table 2 will be employed when percent, rate, correct-to-error ratios and trials-at-criterion standards are used.

Establishing rate criterion standards. Once plotted (typically on logarithmic paper), rate data enable teachers to readily assess the slope and variability of pupil performance (Deno, Morston & Tindal, 1986). Academic/instructional placement decisions based on rate typically are predicated on the teacher obtaining a median performance score and drawing a slope or trend line on the student's chart The median and slope should not be calculated until 6 to 10 days of probe data have been collected (Deno et al, 1986; Lindsley, 1971; Sailor & Guess, 1983). [Evaluation of percent data, it may be recalled, can be conducted with as few as 3 data days although some authors also use 3 data days with rate data (e g., Haring et al., 1978).] Once initial measures (baseline data) are collected and analyzed, direct and frequent measurement (and graphing) should be continued to aid the practitioner in judging the instructional effectiveness of a particular program (Deno et al, 1986; Evans & Evans, 1985; West, 1984)

A desired growth rate can be established by the teacher based on 6 to 10 non-zero data points (Deno et al., 1986; Sailor & Guess, 1983) Detailed procedural descriptions are available elsewhere regarding how to draw trend/growth lines. The short explanation for deriving a growth line that follows is offered more to "demystify" the process than to fully explain the procedure.

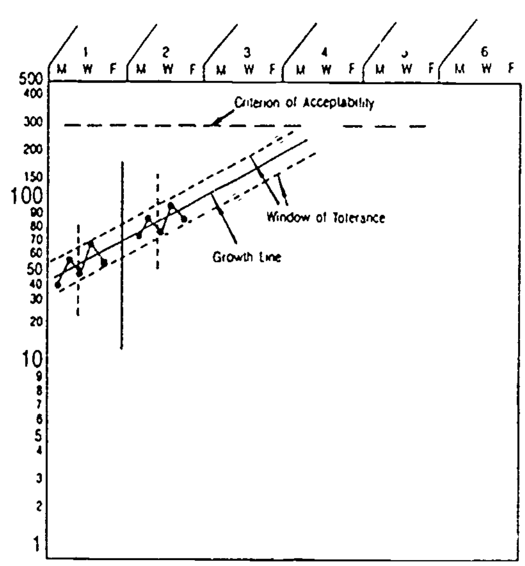
First, to establish a desired growth line--a criterion standard against which teachers can judge the instructional effectiveness of a program, at least 6 data points must be plotted. The data points on the graph are halved Next, the mid-point of the data in the first half is obtained by finding the mid-rank score (i.e., by ordering the scores from lowest to highest) and then locating the mid-day data point A plus sign (+) is recorded on the graph at this so-called mid-point, the point where the mid-day and mid-rank point intersect. This procedure is repeated for the second half of the data. The two plus signs (+) recorded at both mid-points are connected to yield the slope (or trend line). This trend line can be extended and serve as a growth criterion for future performance. Teachers can evaluate the future impact of instruction and subsequent modifications in instruction by simply inspecting and comparing corresponding student performance data (i.e., differing slopes) to the growth line (Deno et al., 1986; Haring et al, 1978; Haring, Liberty & White, 1980)

Decisions on when to modify instruction (i.e., phase change) also may be based on the amount of variability in student performance. A "window of tolerance" (or variability) can be drawn around the growth line to give a a visual boundary to how much variability in performance is acceptable. To create this window, one line is drawn parallel to and above the growth line A second line equidistance, parallel to and below the growth line is made next. If 10 data points, for example, were used to estimate a growth line, at least 3 - 4 points should fall between the top line and the growth line Another 3 - 4 points should fall between the growth line and the bottom line (see Figure 5). Generally speaking, the narrower the window and the more data points within the window, the greater the instructional control. In Figure 5, all data points fall within the window of tolerance--a phase change would not be necessary.

On the other hand, if the window is very wide or many data points (e.g., 4 of 10) fall outside the window, program modifications may be needed A legitimate instructional goal simply may be to reduce variability in student performance Teachers may construct transparent overlays that contain a series of parallel lines which signify a set of different sized "windows of tolerance" The smaller windows, of course, representing more stable data and greater instructional control. Finally, in the absence of peer standards teachers can experiment by making program changes after collecting and plotting the data. The relative effectiveness of each succeeding phase change is judged according to the angle (steepness) of the slope.

Figure 5

Sample Window of Tolerance



Correct-To-Error Ratio and Decision-Making

During initial acquisition of new skills/knowledge a ratio of the number corrects to number of errors can be very useful to the teacher Correct-to-error ratios such as 10.21, 20:18; and 5.16 clearly represent performance with an easily recognized unacceptably high error percentage (67 7%, 47.4%, and 76.2% of the total responses, respectively). By examining the number of corrects in relation to the number of errors and the errors in relation to the total number of responses completed, the teacher can gain a good clinical grasp of the student's learning stage. The higher the number of errors in relation to corrects, the more likely the student is experiencing frustration--the instructional program may need to be sliced back to an easier level When correct to error ratios decrease to less than 10% of the total responses (e.g., 10:1, 24:2, and 132:2), it signifies that the student is advancing from acquisition toward proficiency As such points are identified, the teacher will focus increasingly on speed of performance.

Establishing correct-to-error ratio standards Suffice it to say, by scrutinizing the ratio of corrects-to-errors the teacher can make a quick estimation of whether the material corresponds to a frustration, instructional or independent level of performance for the student. The actual correct-to-error ratio standard that a teacher may establish before making a program more demanding, for example, would include consideration of: (a) the topography of behavior, (b) the importance of that behavior to specific skill/knowledge acquisition in the future, (c) the importance of that behavior to general school success, and (d) the amount of time likely to be required to teach to a stricter criterion level. By examining correct-to-error ratios and modifying instruction accordingly, the teacher can avoid frustrating the student and unwittingly promoting avoidance-motivated behavior

Trials-At-Criterion and Decision-Making

The main purpose of measuring academic performance is to assess achievement and learning and thereafter to design or modify instructional programs in accordance with the educational needs of the student(s). Traditionally, an arbitrarily imposed percent correct figure (e.g., a single demonstration of 80% correct) has been used as a standard for learning (White & Liberty, 1976) However, as White and Liberty (1976) assert, the criterion level selected should define the minimum acceptable performance which facilitates learning subsequent skills In that few low performing or exceptional students are "one-trial" learners--able to master a skill on the first presentation, the introduction of a trials-at-criterion standard may be more functional than a single percent correct score. That is, "x" number of correct responses across "y" number of teaching sessions may constitute a more suitable criterion statement of mastery than a single percent correct score. Unfortunately, guidelines whereby teachers are able to establish optimal criterion standards for any given skill or content area do not exist. Indeed, it is likely that functional standards may vary from student to student, with conservative (i.e , high) standards of mastery recommended for students experiencing difficulty.

Establishing trials-at-criterion standards Traditionally, the literature refers to trials-to-criterion as a basis for determining if a skill is mastered We are employing the term trials-at-criterion to underscore the importance of a repeated performance standard across days Since the majority of underachievers, exceptional learners and students at-risk for dropout are academically delayed, a trials-at-criterion standard is advocated because it incorporates the concept of overlearning (i.e., a high percent/rate correct repeated across trials and/or days, Ivarie, 1986). When employing trials-at-criterion with percent measures, caution must be exercised so that a fixed common demoninator (i.e., equal number of opportunities to respond) is maintained across sessions Too few opportunities to respond probably will not hold educational significance, regardless of the standard imposed. In the final analysis, the worth of any criterion standard must be judged according to its "critical effect"--the impact on present as well as future pupil performance. Teachers should try to identify standards which are most efficient (i e., the least time-consuming) and produce the greatest desired effect. For this reason, the decision of how stringent to make a given trials-at-criterion standard is best made on a pupil-specific basis

As mentioned, one aspect of evaluating "critical effect" is to establish criteria on certain academic (sub)skills and evaluate their affect on students' learning of higher level skills (White & Liberty, 1976) For example, a teacher could assess the affect of a trials-at-criterion standard of 3 and 6 trials on individual and/or group mastery of addition facts After the identified students reach their respective criterion level, multiplication facts are introduced. A comparision to determine which students (i.e., 3 or 6 trial) master the multiplication facts faster and with greater accuracy would yield information on which standard is more useful. Finally, data obtained on student retention of skills/knowledge can be used to guide selection of a trials-at-criterion standard For the instruction of new skills teachers initially can base the selection of a criterion level on experience/data from similiar areas (e.g., criteria for oral sight vocabulary words may be used to assess acquisition of spelling skills)

How to Modify Instruction

Instructional programs may be modified in a variety of ways. Without doubt, some modifications will be more effective and/or more efficient than others. With a data base to guide program modifications the teacher should have more confidence in his/her professional judgment. Nonetheless, a data base and decision rules together are not sufficient to ensure precise, accurate program modifications. To determine the best instructional adaptation, teachers must have some basic knowledge of instructional design. While there are many components of good instructional design, generally speaking, teachers can manipulate four basic elements of any program: (1) the general setting events, (2) the antecedent events, (3) the subsequent events, and (4) the contingency arrangement. Each of these program components is described below followed by more specific guidelines on how to modify instruction when a student is performing at a particular stage of learning.

General setting events General setting events are those conditions under which instruction takes place. Typically, setting events do not exert as great an influence on student performance as do antecedent and subsequent events or as contingency arrangements Setting events include the time of day, noise and lighting conditions of the instructional space, the number of people involved, the physical design of the classroom, the seating arrangement for a lesson, the type of equipment and materials (e.g., print versus an audio-visual presentation) and so on.

<u>Antecedent events</u>. Antecedent events are those instructional cues, prompts, directions and other specific stimuli which come <u>before</u> and directly control (or should control) the learner's behavior For example, the teacher direction, "Jonathan, read this passage carefully" is a specific prompt for behavior from Jonathan. Modification of an antecedent event might include changing the direction (e.g., "Jonathan, I want you to read rapidly and without errors) or altering the actual passage (e.g., dividing the passage into three sentence segments or highlighting difficult words).

<u>Subsequent events</u>. Subsequent events are those events which <u>follow</u> a student's performance (very) closely in time. When these events are positive they are commonly referred to as reinforcement and/or feedback. Subsequent events arranged by the teacher or that exist as part of the instructional material, may or may not be equally reinforcing to all students Self-correcting materials often make provision for clear and prompt subsequent event presentation. Instructional games can be designed to give immediate feedback on the correctness of each response. Similiarly, most educational software is written to supply visual and often auditory feedback on each response. In such cases, the subsequent event reinforces the correct answer. Another example of a subsequent

event is teacher praise or distribution of points provided for correct responses as they occur. Conversely, a frown from a teacher or peer could be an unplanned (and negative) subsequent event As with general setting and antecedent events, subsequent events may be planned or unplanned, either way, they are present in any instructional program. The teacher who consciously adjusts these events and monitors their affect on learning is the teacher who will achieve greater instructional outcomes academically, behaviorally and attitudinally.

Contingency arrangements Contingency arrangements refer to the relationship between student performance/responses and the consequent events that follow the behavior. With good instruction, the correspondence between correct responding and positive reinforcement, for example, is systematic and consistent. The exact relationship between behavior and its consequence can be varied in numerous ways In general, a "one-to-one relationship between behavior and its consequence" is called a continuous schedule Consequent events can be given at fixed times (e.g., every 5 minutes) or for fixed amounts of work (e.g., 1 star for every 10 problems correct) Consequent events also can be delivered on variable schedules. In a variable schedule, after an average of x amount of time has elapsed (e.g., the average time is 5 minutes--the actual delivery of reinforcement varies from 3 to 7 to 5 to 4 minutes, etc.) or y number of responses have been made (e.g., an average of 10 responses earns one a star--stars actually are given after 6, 10, 13, 8 responses, etc.), the subsequent event is delivered following the behavior Continuous schedules of positive reinforcement are known to be an extremely effective way to promote initial learning, whereas variable schedules of reinforcement are essential for maintaining skills/knowledge across time and are more useful for increasing the speed of responding. During acquisition, it may be critical for a student to receive a positive consequence (e.g., praise statement) after each correct response. The teacher should also have a plan for how to consequate each error. After the student begins to perform the skill with increased correctness, the teacher delivers a positive consquence once after every three correct responses. These contingency arrangements, 1:1 and 3:1, represent one teacher consequence for each response and 1 teacher consequence for three responses, respectively Note that contingency arrangements should be planned for both correct and incorrect responses.

In short, decisions on how to modify instruction may be tied to: (a) stages of learning and (b) temporality of events (Gable et al, 1985). Table 3 contains a guide to making instructional changes in relation to the student's stage of learning and the instructional events which occur before and after a student responds Generally speaking, teachers should be cautioned that instructional modifications should be made one at a time. The actual impact of programmatic change will be confounded if several aspects of instruction are simultaneously manipulated.

As seen in Table 3, the stages of learning--Stage 1 (acquisition), Stage 2 (proficiency) and Stage 3 (maintenance), and Stage 4 (generalization), are presented along the left hand side of the table. Antecedent and subsequent events which the teacher may alter are presented in two separate columns. If a student or group of students is experiencing failure during Stage 1, for example, the difficulty of the materials and/or provision for models, prompts and advance organizers might be a first step to modifying antecedent events. Enriching the schedule of reinforcement (e.g, moving from 10:1 to 4:1 behaviors per reinforcer) and/or power of the reinforcement (e.g., switching from giving 1 star to givir 5 minutes of free computer time) are recommended subsequent event modifications. Additionally, the teacher modifying subsequent events is wise to evaluate the immediacy with which positive feedback is provided. A delay in feedback during acquisition is often at the root of poor learning.

During Stages 2 and 3, proficiency building and maintenance, antecedent event changes may include adjusting the pace of presentation, clarifying the relevance of the content and/or simply instructing students to "go faster". Subsequent event modification during these stages typically includes weaning the schedule of reinforcement, increas- ing the amount of work or speed required to receive reinforcement, intro- ducing corrective feedback on errors and instructing students in "self- control/management."

During Stage 3, generalization, antecedent events which are suggested for modification include the introduction of regular class- room and/or grade level materials, varying the topography of the expected response, varying the type/complexity/medium of the presentation, removing direct instruction, and moving into a less restrictive environment. Subsequent event manipulation may include such events as further weaning of the reinforcement schedule, providing for "naturally

Table 3

Guide to Instructional Program Changes By Stages of Learning

Antecedent Events	Subsequent Events
*Provide advance organizers *Provide specific directions *Provide models/prompts *Employ self-correcting materials *Provide controlled practice *Change format of instruction (e.g., small group to one-to-one) *Decrease difficulty of material/length of lesson *Use task analysis to splice skills	*Provide consistent consequation for errors *Reinforce contingently *Enrich schedule of reinforcement *Enhance power of reinforcers *Increase immediacy of positive feedback
*Model fast responding *Present pacing signal *Modify teaching arrangement (e.g., small group to computer assisted) *Adjust pace of presentation *Clarify relevance of content *Instruct to salient apsects of desired performance (e.g., "Go faster.") *Teach self-monitoring, *Remove models/prompts *Provide independent practice *Increase opportunity to practice	*Reinforce rate *Lean schedule of reinforcement *Increase performance criteria *Introduce corrective feedback on errors *Introduce self-recording, self-evaluation, self-reinforcement *Teach goal setting

Table 3: Guide to Instructional Program Changes By Stages of Learning (Continued)

Antecedent Events	Subsequent Events
*Alternate format of instruction (e.g., games, tutorial) *Introduce regular classroom instructional material *Introduce large group instruction *Vary topography of response required *Vary type/complexity/ medium of presentation *Remove direct instruction *Move to less restrictive environment *Increase problem-solving focus of instruction/environment	*Further lean the schedule of reinforcement *Review student performance periodically/ provide specific feedback *Provide for naturally occurring reinforcement *Provide social reinforcement *Provide variable schedule of reinforcement

occurring" reinforcers, and review and provision of periodic feedback to students.

Stowitschek, Gable and Hendrickson (1980) point out that it is probably wise to first modify the subsequent event because materials adaptation usually requires a greater time investment and expertise on the part of teachers than modifying consequences. On the other hand, ideally the decision to modify a program should be based on what is most likely to improve student outcomes, not its affect on teacher workload. Many commerical and teacher-made programs, however, lack provision for clear, concise consequation of pupil performance. Therefore, modifying subsequent events remains a good initial step to program modification, particularly during the proficiency and maintenance stages. Even so, given the limited empirical evidence to support specific program changes (Fuchs, 1986), the options shown in Table 3 are presented as tentative recommendations. Teachers are advised to establish and maintain files with copies of program modifications that were especially effective By separating graphs and program descriptions by content or skill areas, the teacher can accumulate a personal library of proven instructional modifications from which to draw on for future instructional decisions.

Use of Normative Standards

Yet another facet to instructional decision-making is the use of normative peer-referenced academic standards. By noting on each graph a peer performance standard, it becomes possible to judge the student with mild to moderate performance deficits against the performance of peers who are succeeding on tasks which the student aspires to master (e.g., mainstream classroom peer performance in grade level materials). Peer performance standards may be established in relation to one representative peer or a group of peers. Caution must be exercised in using the performance data of a single peer to set criterion standards for the target student. Each child is unique and his/her learning pattern may not be comparable to the target student on a given skill or at a given point in time; on the other hand, the average performance of peers may be a more reasonable aim or standard for underachieving students. Teachers may gather data on peers in their own classrooms or from other classrooms in the building Peer performance data collected several times a year will help the teacher know if his students are within the range of acceptability for that school or school district. Knowledge and utilization of local normative standards, however, must be tempered by the realization that "teacher tolerance" and expectations vary across teachers and from student to student (Evans et al., 1986).

Guidelines for Establishing a Data-Based Classroom and Making Data-Based Instructional Decisions

The majority of preservice teachers are taught to examine the impact of their instruction according to measurable changes in pupil performance and achievement (e.g., Kerr & Nelson, 1983). From a practitioner's viewpoint, one obstacle to using data-based procedures is the belief that such procedures are too time-consuming (Wesson et al., 1984) Further, data-based programs are believed to take time away from teaching to test (Sailor & Guess, 1983). Additionally, the fact that few teachers engage in the use of direct and repeated measures and data charting may be attributable to an absence of reinforcement for becoming effective data managers Finally, the lack of guidelines to assist teachers in carrying out the complex task of addressing the educational needs of a heterogenous group of students is apparent. Therefore, the following recommendations for establishing a data-based program and implementing data-based decisions are reiterated to facilitate the efforts of teachers who desire to bring the virtues of quality data analysis into practice in their classrooms:

The Data-Based Classroom Program

1 Begin with one student (and one subject area) Set performance standards Collect data, chart and analyze performance Make data-based decisions

2 Collect data only on essential and/or priority skills

3. Graphically depict data immediately (or as soon as possible) after measuring performance and collecting the data

4 Learning may be conceptualized as progressing through the stages of: acquisition, proficiency building, maintenance and generalization The learning stage at which a student is performing should be used to select the performance measure

5 Establish a data management station for scoring, charting and providing students feedback on their performance.

6. Administer written probes to groups of students. Teach students to administer probes to other students. Teach students to administer their own probes.

7. Teach students to chart their own performance and set their own performance objectives. Volunteers and parents also can be taught to administer probes and collect and chart data.

8 Share charted data with students, parents and school personnel

9. Use student charts to support the need for new instructional materials, equipment or other student services (e.g., speech).

10 Teach yourself or obtain training on how to become more efficient in data collection, charting, analysis and program modification.

Data-Based Instructional Decisions

1 Direct and repeated measurement is the best assessment approach for monitoring student progress and evaluating the merit of classroom instruction

2 Percent and rate data are the student performance measures most frequently used in education. Percent data are especially useful during the acquisition stage of learning, while rate data are essential during proficiency building.

3 Several data points (usually 3 to 10) are needed to determine whether a phase change is necessary (i.e., whether instruction should be modified).

4. Equal interval or logarithmic graphs may be used to present data

5 Growth and/or trend lines on student charts can be used by teachers to establish performance standards

6. Both correct response trends and incorrect response trends should be examined before instruction is modified

7 Correct-to-error ratios are very helpful for gaining a quick estimation of a student's learning stage

8. High trials-at-criterion standards may be beneficial for the student experiencing a persistent learning difficulty

9 Variability is a dimension of student performance that should be examined carefully--the greater the variability, the less instructional control.

10. When in doubt about whether or not to modify a program either

    (a) collect additional data or

    (b) reexamine the basic data decision rules pertaining to trend analysis.

Summary and Conclusion

A growing number of school age children and youth are trapped in a failed educational system. Although an empirical approach is not common in most classrooms (Tawney, 1984; Wesson et al., 1984), data-based instruction is recognized by experts as an important feature of classrooms that successfully serve children with learning and behavioral difficulties (Gable et al., 1985). By graphing and visually inspecting pupil performance data, teachers can apply decision rules, adjust instruction and reduce the time students engage in nonproductive programs.

This monograph represents an effort to consolidate, for the practitioner, information on data-based instruction and data-based decision-making. As we have discussed, an ample body of research has accumulated to guide decisions on <u>when</u> to modify instruction; however, less is known about <u>how</u> to modify instruction (Fuchs, 1986). Consequently, the wisdom of any instructional decision should be confirmed on the basis of ongoing evaluation of pupil performance (Eaton, 1978). By selecting an appropriate performance standard and applying the known decision rules, the extent to which teachers produce gains in students with histories of academic failure is likely to be enhanced.

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